Influence of Land Cover Urbanization on the Biological Condition of Puget Sound Lowland Streams

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Extended Abstract (Excerpted from Morley and Karr, *in review*)

Metropolitan areas now cover more than 19% of the U.S., and include more than 75% of the nation's population (Stoel 1999). As one consequence, many urban streams today are highly engineered channels designed more for flood control and sediment transport than ecological considerations (Roesner 1997). Across the United States, 36% of river miles surveyed for the 1994 National Water Quality Inventory failed to support healthy aquatic communities (U.S. EPA 1995), and recent studies find freshwater species extinction rates as high as for tropical forests (Ricciardi and Rasmussen 1999). In the Pacific Northwest, the National Marine Fisheries Service recently added nine populations of Pacific salmon and trout to the endangered species list—the first time such protection has extended to a major metropolitan area of the United States.

Efforts to protect and restore urban streams have traditionally focused on physical channel conditions and chemical water quality. The objective of this study is to use the biology of these streams—measured with the multimetric index of biological integrity (B-IBI) based on benthic macroinvertebrates—to assess stream condition. This index integrates empirically tested biological attributes (called metrics) of taxa richness, disturbance tolerance, and feeding ecology to provide a numeric synthesis of site condition (Kerans and Karr 1994; Fore and others 1996; Karr and Chu 1999). In this study we investigate how B-IBI responds when humans alter land cover over multiple spatial scales (see Morley and Karr (*in review*) for greater detail on study design and methodologies).

Between 1997 and 1999, we collected invertebrate samples from 16 second and third order streams in the Puget Sound lowlands of Western Washington. We selected 45 study sites to reflect a gradient of urban development, but with a limited range in elevation (10-200m), gradient (0.5-1.5%), and drainage area (5-69km^2). Fourteen of the 16 study basins typically had one to three invertebrate monitoring sites; Little Bear and Swamp Creek basins included nine and eight sample sites, respectively, so that we could examine within-basin variation in biological condition. Urbanization was characterized by a 1998 satellite land cover classification and was measured across three spatial scales: sub-basin, riparian, and local.

B-IBI and component metrics were strongly correlated with land cover for all streams and at all spatial scales. Across all study sites, urban land cover correlated inversely with B-IBI at each of the three spatial scales: sub-basin ($R^2 = .54$, $p < 0.001$), riparian ($R^2 = .56$, $p < 0.001$), and local ($R^2 = .50$, $p < 0.001$). Of the ten metrics that comprise B-IBI, seven were better predicted by sub-basin rather than local land cover. Regionally, a multiple regression of local and sub-basin urban land cover explained 61% of variability in B-IBI ($p < 0.001$). Within the intensely-sampled Little Bear Creek basin, B-IBI was very closely correlated with local land cover change alone ($R^2 = 0.82$, $p < 0.001$). Invertebrates at nearly all sample sites indicated mild to severe biological degradation.

Our results indicate that the effectiveness of localized patches of riparian corridor in maintaining biological integrity varies as a function of basin-wide urbanization. When overall basin development is low to moderate, natural riparian corridors have significant potential to maintain/improve biological condition. Protecting high-quality wetland and riparian areas that persist in less-developed basins may also serve as a source of colonists (be they plants, invertebrates, fish, etc.) to other local streams that are subject to informed restoration efforts. At the same time, even small patches of urban land conversion in riparian

areas can still severely degrade local stream biology. As both a conservation and restoration strategy, protection and re-vegetation of riparian areas is critical for preventing severe stream degradation, but these measures alone are not adequate to maintain biological integrity in streams draining highly urban basins (Roth and others 1996).

The survival of wild salmon in the Pacific Northwest depends on many factors, crucial among them being high quality streams for spawning and rearing of young. Benthic invertebrates are excellent indicators of stream condition in that they are key components of the aquatic foodweb, sensitive to a variety of human disturbances, often long-lived, and not migratory or artificially stocked (Rosenberg and Resh 1993; Fore and others 1996). B-IBI in the urban streams of this study responded strongly to changes in land cover at multiple spatial scales. The response of individual metrics to land cover further demonstrates that stream biota are sensitive to impacts expressed at both large and small spatial scales (see Allen and others 1997). To achieve meaningful long-term biological recovery, conservation and restoration efforts must take a broad focus. This entails looking beyond narrow conceptions of localized in-stream habitat manipulation (see Larson and others, *in press*) to examine additional local factors and the cumulative effects of multiple impacts operating across the entire basin (Ziemer 1997). Biological assessment tools such as B-IBI are essential elements in this process.

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